



LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

Saturated Zone Denitrification at California Dairies

M. J. Singleton, B. K. Esser, J. E. Moran, W. W. McNab, H. R. Beller

March 1, 2006

International Conference on The Future of Agriculture:
Science, Stewardship, and Sustainability
Sacramento, CA, United States
August 7, 2006 through August 9, 2006

Disclaimer

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

Saturated Zone Denitrification at California Dairies

Michael J. Singleton¹, Brad K. Esser¹, Jean E. Moran¹, Walt W. McNab², Harry R. Beller²

Denitrification can effectively mitigate the problem of high nitrate concentrations in groundwater under dairy operations by reducing nitrate to N₂ gas, at sites where biogeochemical conditions are favorable. We present results from field studies at central California dairies that document the occurrence of saturated-zone denitrification in shallow groundwater using biomolecular indicators, stable isotope compositions of nitrate, and measurements of dissolved excess N₂ gas. Excess N₂ concentrations provide a measure of the extent to which nitrate in groundwater has been partially or completely denitrified. Abundant excess N₂ and young ³H/³He apparent groundwater ages indicate high denitrification rates near manure lagoons where multiple lines of evidence indicate seepage of lagoon water into the groundwater system. Natural tracers of lagoon water include high chloride and dissolved organic carbon concentrations, distinctive trace organic compounds, and high groundwater δ¹⁸O values (relative to other recharge sources). Proximal to the lagoons, NH₄⁺ may be present in groundwater, but is strongly adsorbed on to sediment particles. Bubble formation in the lagoons causes the exsolution of other gases (N₂, Ar, Ne, He, etc.), which partition into the gas phase and strip the lagoon water of its dissolved gas load, providing a unique tracer of lagoon seepage in groundwater.

This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

¹*Chemical Biology & Nuclear Science Division, Lawrence Livermore National Laboratory, P.O. Box 808, L-231, Livermore, California, 94551; Telephone (925) 424-2022; Fax (925) 422-3160; Email singleton20@llnl.gov*

²*Environmental Restoration Division, Lawrence Livermore National Laboratory, P.O. Box 808, L-530, Livermore, California, 94551*